



Advanced Materials

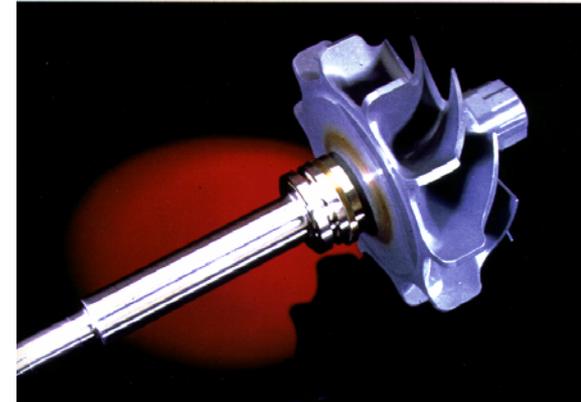
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Oak Ridge National Laboratory
and
Debbie Haught
U.S. Department of Energy

DER Peer Review
March 12-14, 2002

Materials Program Focuses on Needs of Industrial Gas Turbine and Microturbine Contractors



- **Recuperator Materials**
 - Creep-resistant Materials (to 700°C)
(Materials Suppliers, ORNL)
 - Oxidation-resistant Materials (above 700°C)
(Materials Suppliers, ORNL)
 - Microturbine Materials Test Facility (ORNL)
- **Si₃N₄ Ceramics and CFCCs**
 - Environmental Stability (Honeywell, Kyocera, St. Gobain, ORNL)
 - Mechanical Properties (UDRI, ORNL)
 - EBC and TBC Coatings (ORNL)
 - Reliability and Life Prediction (NASA, ORNL)
 - NDE (ANL)
- **Heat Sinks**
 - High Conductivity Carbon Foam (ORNL)





Materials Projects Were Reviewed by Microturbine Manufacturers During the Summer of 2001

Recuperator Review Team	
Reviewer	Affiliation
Jeff Willis	Capstone
Tom Sebestyen	Consultant
Mano Manoharan	General Electric
Scott Wright	Honeywell
Jim Nash	Ingersoll-Rand
Mike Ward	Solar Turbines
Daniel Mosher	UTRC
Tom Rosfjord	UTRC
Ceramics and Power Electronics Review Team	
Matt Stewart	Capstone
Tom Sebestyen	Consultant
Curt Johnson	General Electric
Bjoern Schenk	Honeywell
Scott Wright	Honeywell
Dave Carruthers	Kyocera
Bob Licht	Saint-Gobain
John Holowczak	UTRC

The Recuperator Panel Made a Number of Recommendations

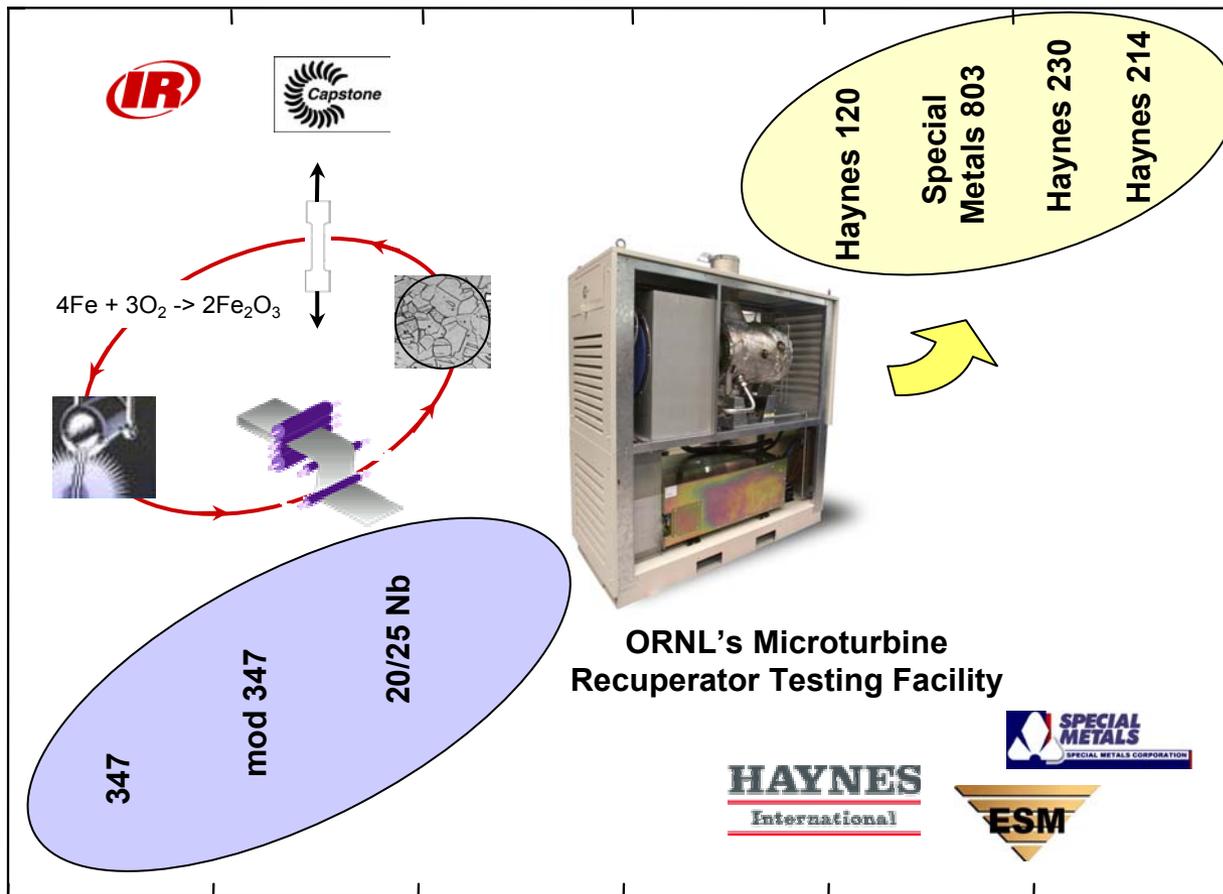


- **Recuperator projects need to be better coordinated**
- **Recuperator manufacturers and materials producers need to be part of the team**
- **Materials work should be extended to include fatigue**
- **The projects being funded are essential to near term success and commercial acceptance**

Recuperator Team Has Been Expanded to Include Microturbine OEMs and Materials Suppliers



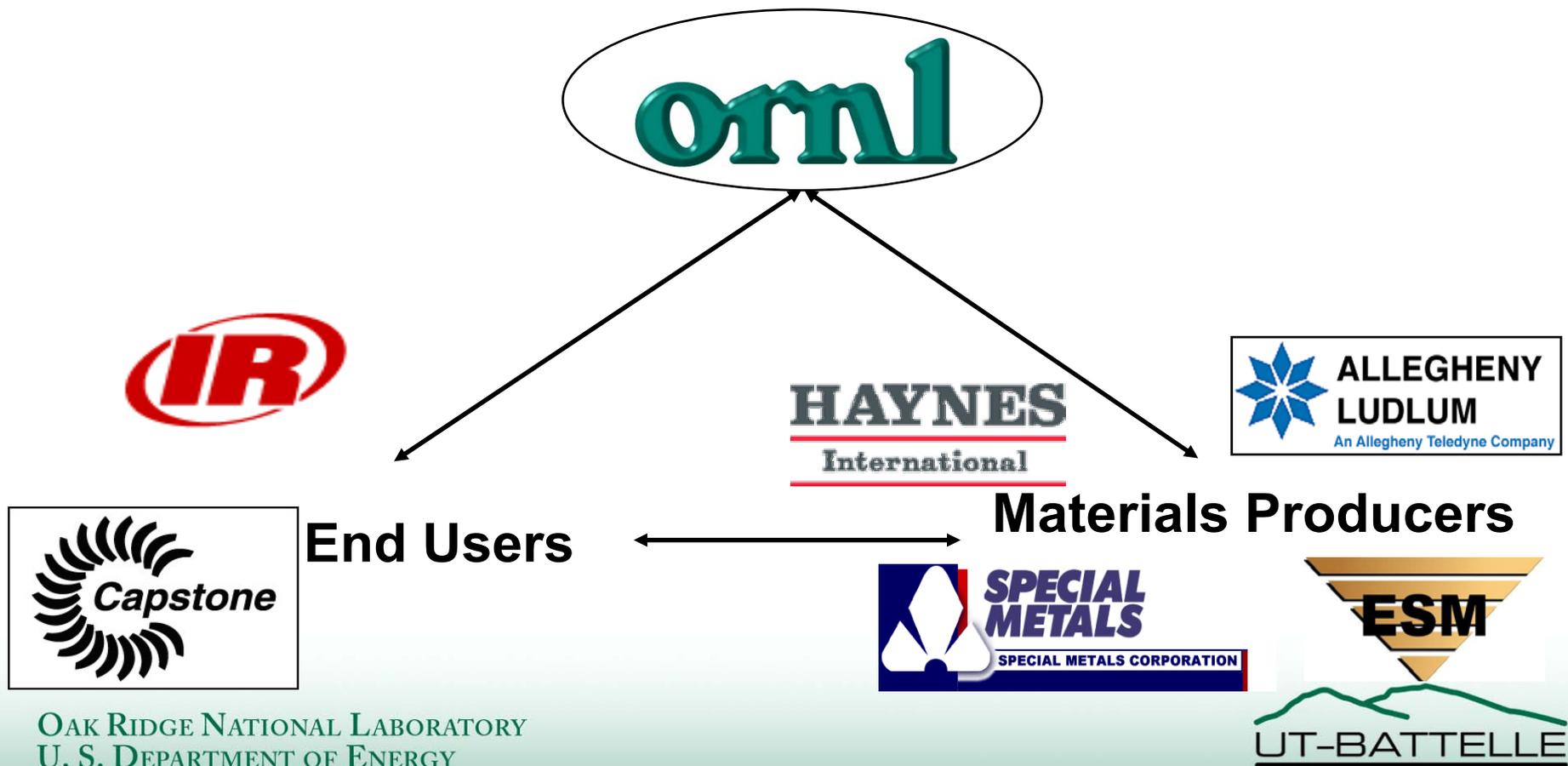
600°C 650°C 675°C 700°C 750°C 800°C 850°C



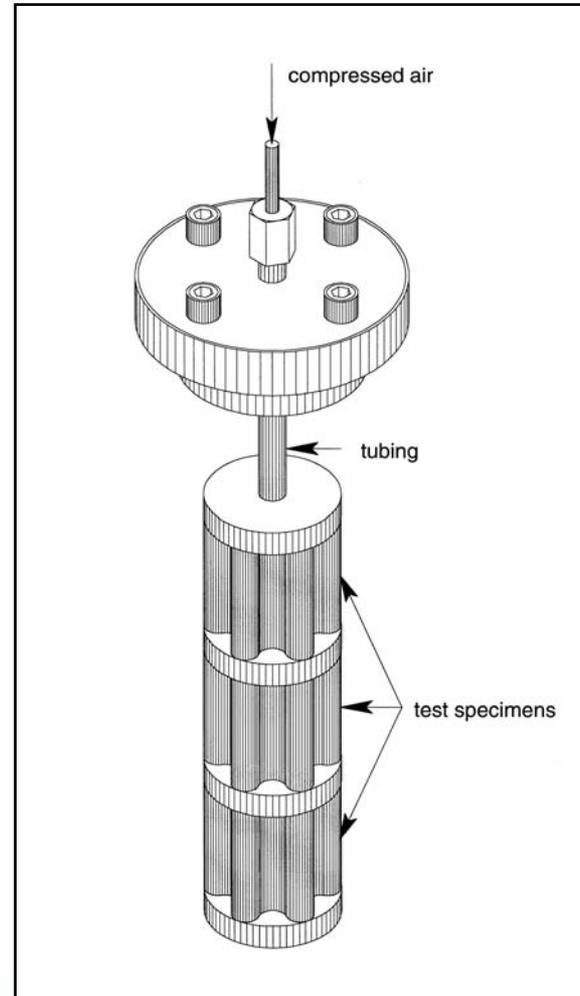
Advanced Materials Are Being Developed, Evaluated and Manufactured in A Collaborative Effort



Materials R&D Capabilities and Expertise



Materials Developed by This Team are Being Evaluated in A Test Facility

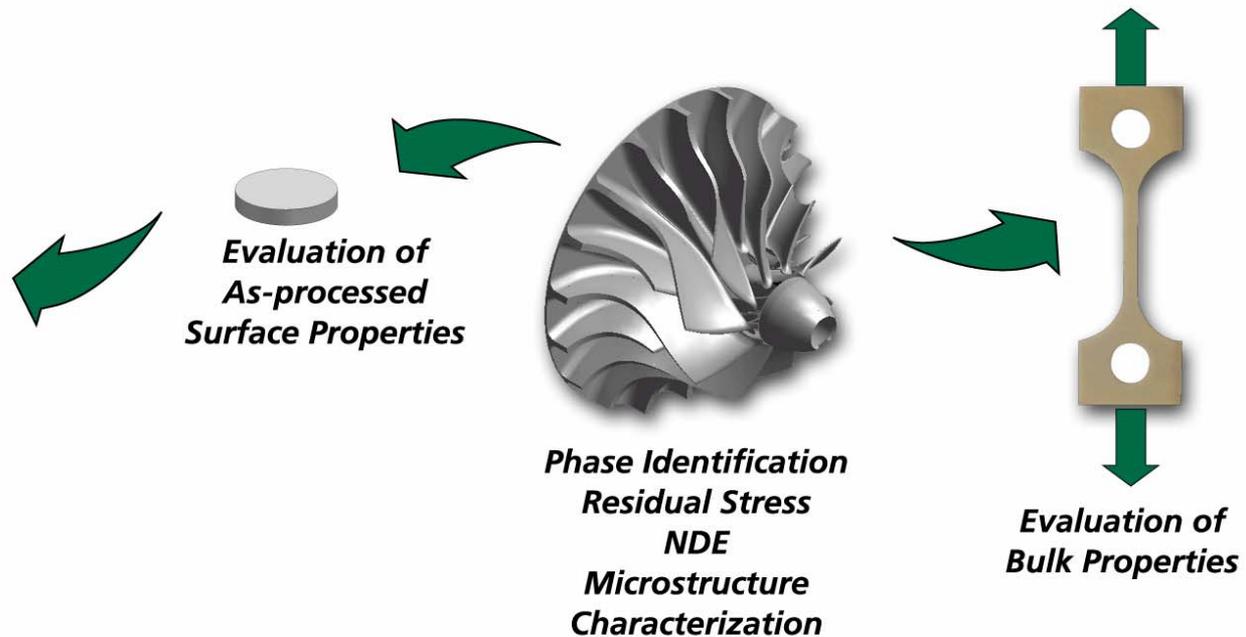


The Ceramics Panel Made a Number of Recommendations



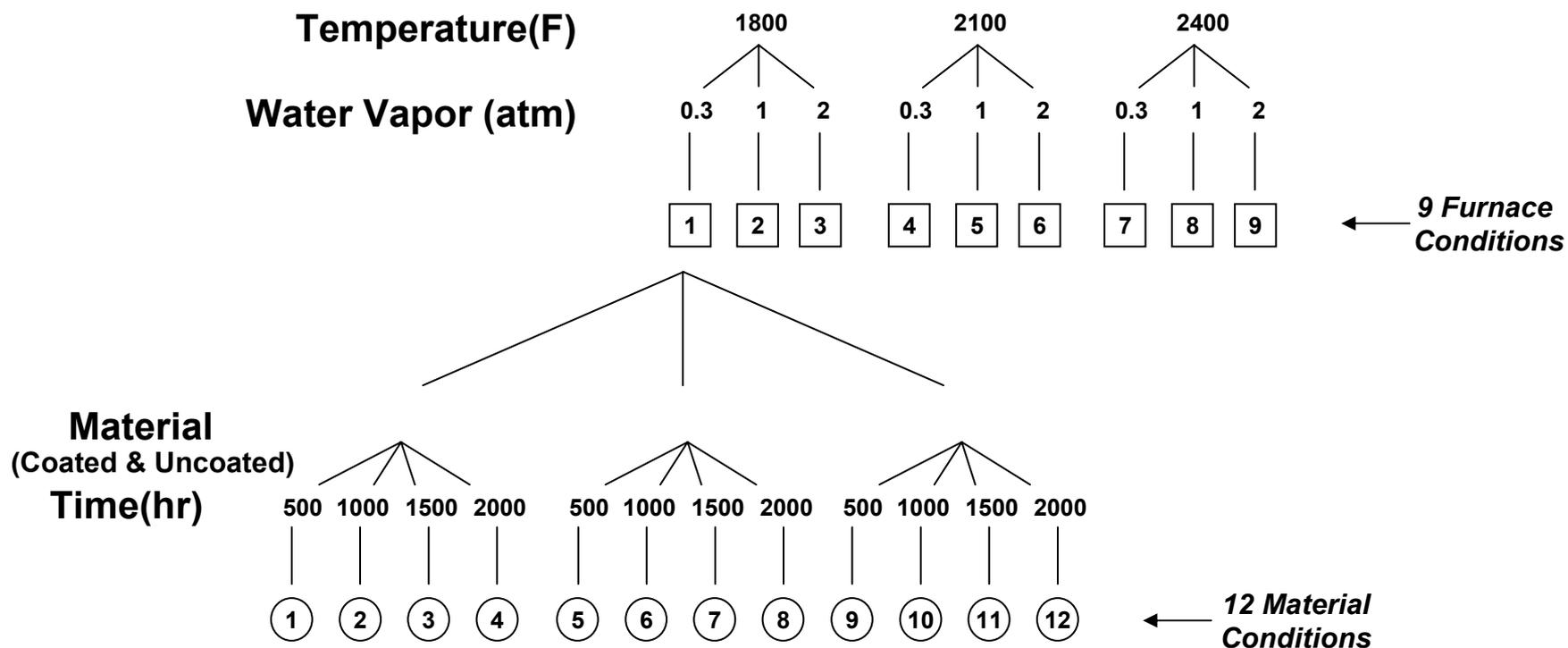
- **Need better understanding of the difference between as-processed and machined surfaces**
- **Need more participation by other manufacturers**
- **The activities being funded are highly essential to long-term objectives of the program**
- **Good, reliable data and a workable materials database is needed**

Methodology was Developed to Measure Properties of Complex-Shaped Ceramic Components





Experimental Design was Developed from the Scoping Study

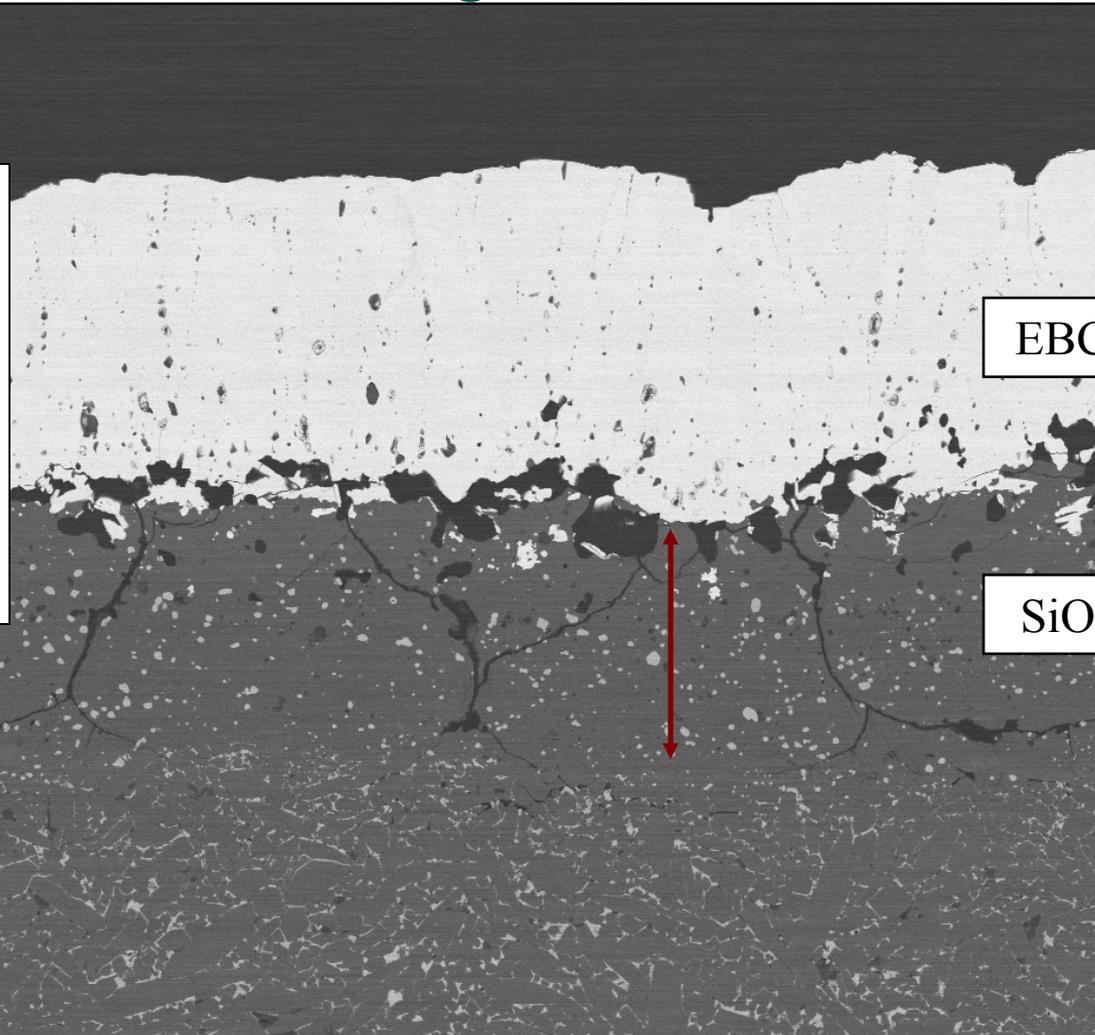


EBCs Are Being Evaluated After Exposure in Keiser Rig



EBC issues:

- adherence
- phase stability
- sintering
- diffusion barrier
- volatilization resistance?



EBC

SiO₂ Scale

10 μm

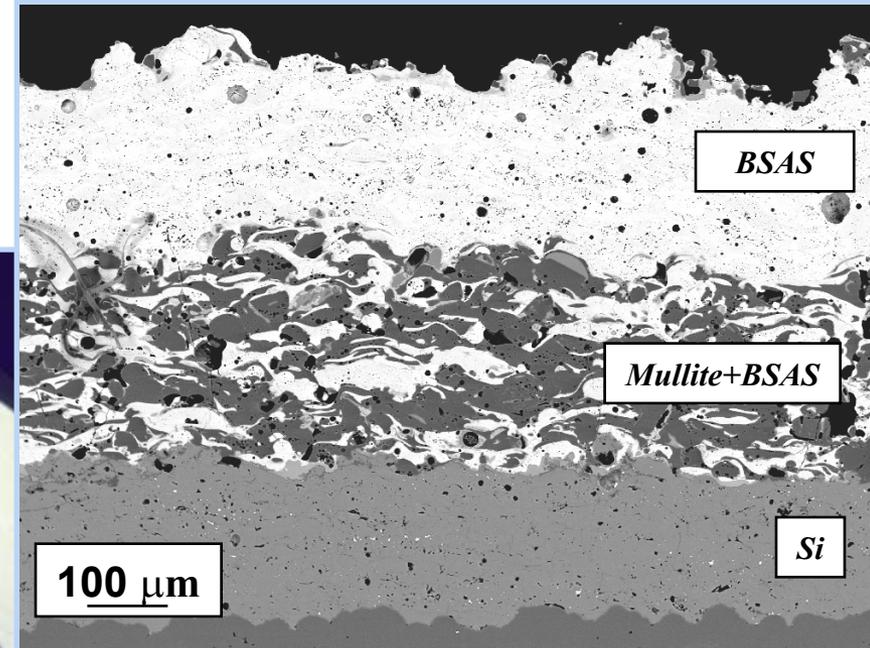
CFCC Combustor Liner Development For Microturbines Will Benefit From ORNL's Extensive Experience In Evaluating CFCC Liners For Stationary Gas Turbines



Set of CFCC liners that just ran in a 13,937 h engine test at Chevron test site in Bakersfield

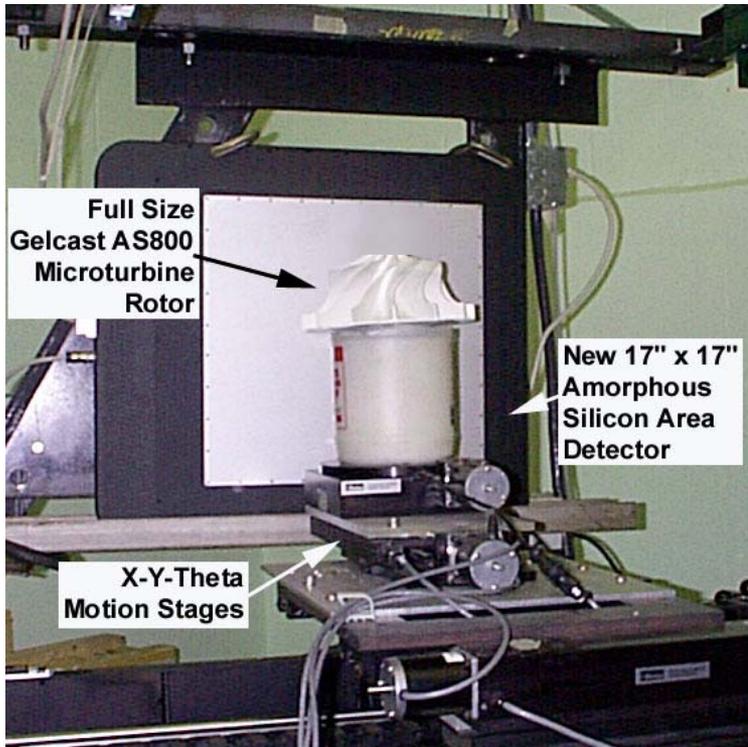
*13" Inner MI Liner
GE Power Systems Composites*

*30" Enh. SiC/SiC Outer Liner
GE Power Systems Composites*



Environmental Barrier Coatings (EBCs) are used to protect the Si-based CFCC liners from environmental attack during engine exposure.

In Process NDE is Being Developed to Reduce Cost and Improve Reliability

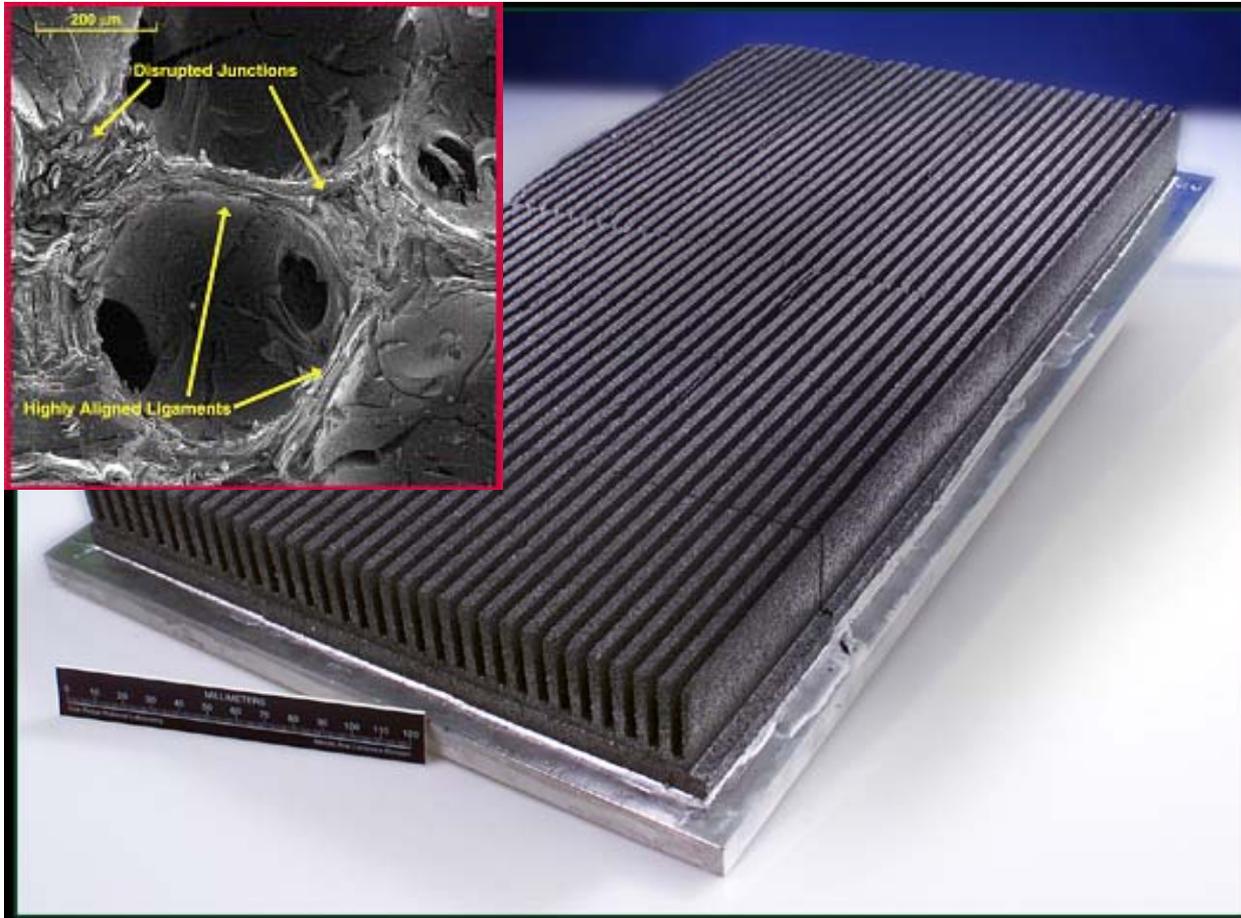


Goal – Reject flawed parts prior to final processing and proof testing

Accomplishments:

- **<200 μ m cracks in full size rotor detected and displayed**
- **High speed, <5 minute acquisition demonstrated**

Prototype Heat Sinks Are Being Fabricated From High Conductivity Carbon Foam

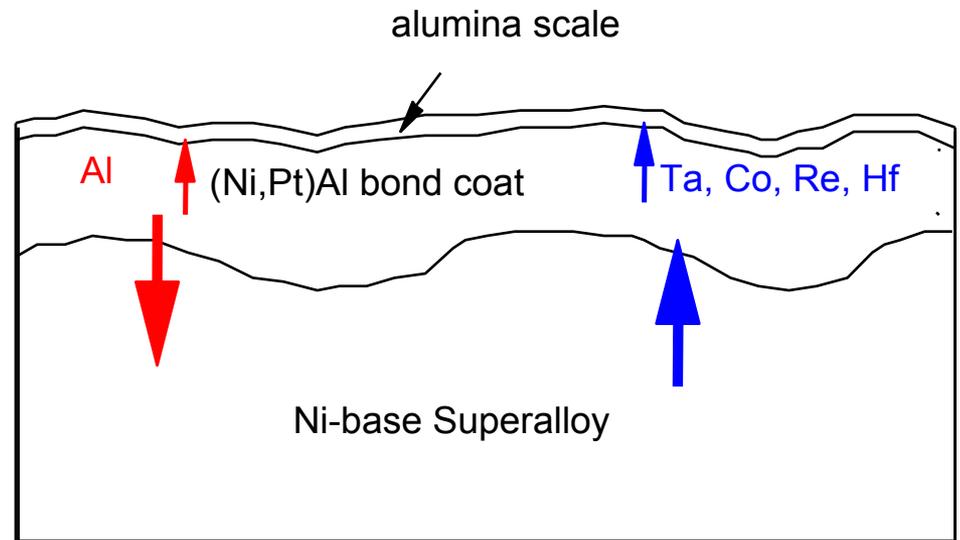


Diffusion Barriers To Extend Performance of State-of-the-Art TBCs



Long-term high-temperature performance of aluminide bond coats is degraded by:

- loss of Al to substrate by inward diffusion
- loss of Al due to oxidation/corrosion (change from β (NiAl) to γ' (Ni_3Al) phase)
- interdiffusion of substrate elements (degrade oxidation resistance of coating)

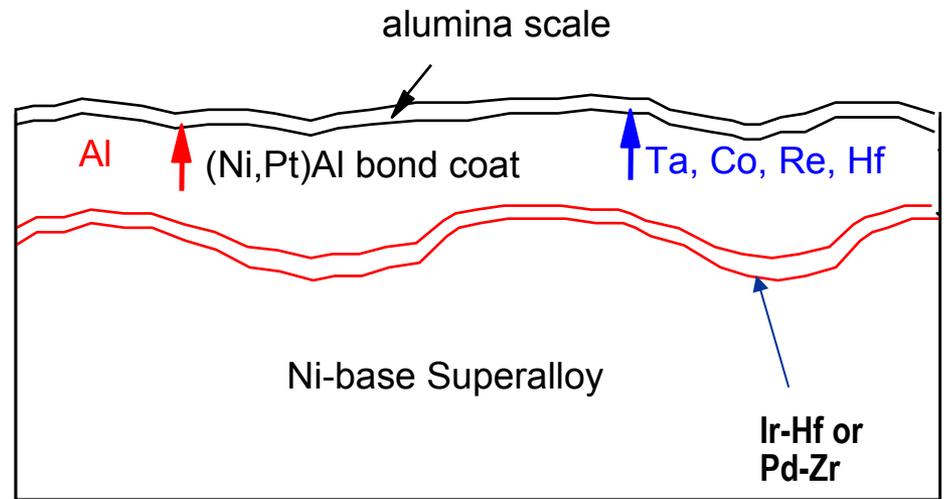


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Ongoing Materials Projects Support the Industrial Gas Turbine and Microturbine OEMs



- **Collaborate with ceramic suppliers to evaluate the mechanical properties and environmental stability of silicon nitride**
- **Develop and evaluate corrosion-resistant coatings for silicon nitride**
- **Develop creep- and oxidation-resistant metals for higher temperature recuperators to develop and test improved recuperator materials**
- **Collaborate with OEMs and material suppliers to evaluate CFCCs for gas turbines and microturbines**